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High temperature sulfidation of carbon steel heater tubes in gas condensate containing sulfur compounds

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ABSTRACT

Being inexpensive and readily available, carbon steel is considered as the material of choice for majority of applications in the petroleum refining industry. However, carbon steel is unsuitable for applications involving certain corrosive species such as sulfur compounds. In this work the causes of heater tubes rupture in BPC have been investigated. Our results indicate that the major cause for premature failure is high temperature sulfidation along with erosion due to turbulence. This study shows that the corrosion rate of the tubes does not follow McConomy law and it is much higher than the one predicted by McConomy curves. As a result, carbon steel is not a suitable material for such heater tubes, where the gas condensate contains high amount of sulfur compounds especially mercaptans.

1. Introduction

To operate profitably, modern refineries and petrochemical plants must run at high temperatures and pressures with a minimum of downtime for maintenance [1]. Direct fired heaters are used to heat the crude oil for processing. Increasing use of sour crude feedstock along with efforts for having greater throughputs are aggravating the crude heater corrosion problems [1]. High temperature corrosion problems in refineries are of considerable importance. Equipment failures can have serious consequences, because processes at high temperatures usually involve high pressures as well. By having the hydrocarbon streams around, there is always the danger of fire when a rupture occurs [2].

Corrosion by various sulfur compounds at temperatures between 260 and 540 °C is a common problem in many petroleum refining processes and occasionally, in petrochemical processes [2–4]. The sulfur compounds decompose thermally during processing into constituents such as hydrogen sulfide and mercaptans (organic sulfur compounds). In sufficient quantities (above 0.2 wt.%), these compounds are known to be corrosive to carbon and low alloy steel at temperatures above ~230–290 °C and up to 455 °C [5–7]. The relative corrosivity of sulfur compounds generally increases with temperature [8]. Sulfidation corrosion of piping and equipment within the refining industry continues to be a significant cause of leaks leading to equipment replacements, unplanned outages, and incidents associated with large property losses and injuries [9].

To predict the relative corrosivity of crude petroleum and its various fractions in the absence of hydrogen, sulfidation corrosion rates vs. temperature data have been elaborated on the basis of industrial experience. First data were provided by a survey conducted by the American Petroleum Institute (API) Subcommittee on Corrosion in 1961 [10].

When sulfur is the only contaminant, McConomy curves are used to predict the relative corrosivity of crude oils and their various fractions as well as the effect of operational changes on corrosion rates already experienced in the field [5–7,10,11]. However, estimated corrosion rates from McConomy curves include considerable uncertainty. As a result, the estimates

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